CALCULATING DOSE TO NON-HUMAN BIOTA

Purpose

This Meteorology and Air Quality Group (MAQ) procedure describes process for calculating radiological dose to non-human biota in accordance with the requirements of DOE Order 5400.5 and DOE-STD-1153-2002 for inclusion in annual environmental surveillance reports (ESRs) and other ecological risk assessment documentation.

Scope

This procedure applies to the calculation of radiological dose to non-human biota from exposure to soils, sediment, and water containing radionuclides released by current or past Laboratory operations.

In this procedure

This procedure addresses the following major topics:

Hazard Control Plan

The hazard evaluation associated with this work is documented in MAQ-Office.

Signatures

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General information about this procedure

Attachments

This procedure has no attachments.

History of revision

This table lists the revision history and effective dates of this procedure.

Revision	Date	Description Of Changes
0	5/12/04	New document.

Who requires training to this procedure?

The following personnel require training before implementing this procedure:

- individuals responsible for calculating doses to biota reported in the ESR or other ecological risk assessment documentation.

Annual retraining is required and will be by self-study ("reading") training.

Training method

The training method for this procedure is "**self-study**" (reading) and is documented in accordance with the procedure for training (MAQ-024).

Prerequisites

In addition to training to this procedure, the following training is also required prior to performing this procedure:

- Advanced training in radiation protection, ecological risk assessment, dose modeling, and environmental sampling and analysis.
- One of the following:
  - Dose modeling using the spreadsheet-based RAD-BCG Calculator developed for the DOE's Graded Approach to Evaluating Radiation Doses to Aquatic and Terrestrial Biota (DOE-STD-1153-2002) [training can be attained through reading the standard documentation, working with the spreadsheet, and/or working with someone familiar with the model.]; OR
  - Dose modeling using the code RESRAD-Biota developed for the DOE's Graded Approach to Evaluating Radiation Doses to Aquatic and Terrestrial Biota (DOE-STD-1153-2002) [training can be attained through reading the standard documentation, working with the spreadsheet, and/or working with someone familiar with the model.]

General information, continued

Definitions specific to this procedure

Aquatic biota: organisms that inhabit water systems.

Biota: plant or animal life inhabiting a specific region; in this context, the term biota refers to free-living, non-domesticated, non-human life.

Biota concentration guide (BCG): the limiting concentration of a radionuclide in soil, water, or sediment that would not lead to exceeding dose limits for the protection of biota in the environment.

Dose: a general term used to describe the energy received by and biological effect to a receptor of ionizing radiation particles or rays from radionuclides in the environment.

Environmental media: a discrete portion of the environment, animate or inanimate, that may be sampled or measured directly.

Environmental monitoring or surveillance: the collection of samples of water, sediment, soil, foodstuffs, biota, or other media to measure the presence external radiation or radiological constituents in order to evaluate effects on resident biota.

External or direct exposure: exposure to doses received from radiation (e.g., photon or neutron) sources external to an organism's body.

Internal exposure: exposure to doses received from radiation sources deposited within an organism's body through ingestion, inhalation, or other respiratory processes, or absorption through the body surface.

Riparian biota: organisms that inhabit land surfaces adjacent to or within stream courses.

Terrestrial biota: organisms that inhabit the land surface.

Background

Introduction

This procedure describes the process for applying the DOE graded approach (including screening and detailed analysis) to evaluating compliance with DOE dose limits for the protection of aquatic and terrestrial biota from releases of radionuclides from Laboratory operations.

Dose limits

The DOE technical standard sets forth dose limits that are used to demonstrate whether populations of plants and animals are adequately protected from the effects of ionizing radiation released by Laboratory operations. These limits are:

- Aquatic animals: the absorbed dose to aquatic animals should not exceed 1 rad/day (10 mGy/day) from exposure to radiation or radionuclides released into the aquatic environment. This dose limit is specified in DOE Order 5400.5.
- Terrestrial Plants: the absorbed dose to terrestrial plants should not exceed 1 rad/day (10 mGy/day) from exposure to radiation or radionuclides released into the terrestrial environment.
- Terrestrial animals: the absorbed dose to terrestrial animals should not exceed 0.1 rad/day (1 mGy/day) from exposure to radiation or radionuclides released into the terrestrial environment.

Avoiding measurable impairment of reproductive capability is deemed to be the critical biological effect in establishing these dose limits.

Data assembly

Data sources

The DOE graded approach to biota dose evaluation was designed to minimize the need to collect additional data above and beyond data sets normally available through routine environmental monitoring and surveillance programs. Radionuclide data for soils are typically provided by the Soils, Foodstuffs, and Biota sampling program within the Meteorology and Air Quality Group (RRES-MAQ) for the annual ESR. Water and sediment data are typically provided by the Water Quality and Hydrology Group (RRES-WQH). Other sources of data may be used as appropriate from other sources such as the Remediation Services Program (RRES-RS).

Steps for data assembly

To assemble data, perform the following three steps.

Step	Action
1	Consider the sources, receptors, and routes of exposure. Three conditions must be present for a dose evaluation: • Radioactivity as a result of Laboratory operations should be present or anticipated to be present in the environment • Receptors (plants and animals) should inhabit the vicinity Laboratory releases • Routes of exposure should exist from the releases to receptors
2	Define the area of the evaluation. In general, the screening approach assumes that the exposure area is infinite and organisms spend 100% of their lifetime in the exposure area. Evaluators may choose to modify these assumptions for more detailed analysis based upon site- and receptor-specific conditions.
3	Collect and organize the data on radionuclide concentrations in environmental media. Data from the sources mentioned above should be organized by location and media and be applicable to the evaluation area defined in Step 2. Maximum concentrations measure in environmental media should be used in the initial application of the general screening approach.

General screening

Compare data from environmental media to generic BCGs

The evaluator compares measured data on radionuclide concentrations in environmental media to generic biota concentration guides (BCGs) presented in DOE-STD-1153-2002.

Sum of the fractions rule

The evaluator uses a sum of the fractions approach in comparing data to BCGs when multiple radionuclides are present. That is, the sum of the ratios of each radionuclide measurement to its corresponding BCG for each medium are summed across appropriate media. The total sum of fractions should not exceed 1 if conditions in the evaluation area are to be considered protective of biota.

This relationship for aquatic and terrestrial systems is as follows:

For each environmental medium (soil, water, and sediment), for radionuclides a, b, … n with concentrations C_a, C_b, …C_n and corresponding screening values of BCG_a, BCG_b, … BCG_n, then

- Aquatic systems

$$[C_a \div BCG_a + C_b \div BCG_b + \ldots + C_n \div BCG_n]_{water} + [C_a \div BCG_a + C_b \div BCG_b + \ldots + C_n \div BCG_n]_{sediment} < 1$$

- Terrestrial systems

$$[C_a \div BCG_a + C_b \div BCG_b + \ldots + C_n \div BCG_n]_{water} + [C_a \div BCG_a + C_b \div BCG_b + \ldots + C_n \div BCG_n]_{soil} < 1$$

Site-specific screening

Overview

Site-specific screening allows the evaluator to apply knowledge of site-specific conditions to refine the biota dose screening. Parameters representative of radionuclide concentration values in place of maximum values may be considered in addition to evaluating receptors representative of the local site.

Steps in site-specific screening

To assemble data, perform the following steps:

Step	Action
1	Assess the representativeness of the input data on radionuclide concentrations and the delineation of the evaluation area. Consider using mean, median, or upper confidence levels for radionuclide concentrations. Consider refining the evaluation area on the basis of spatial and temporal distribution of the data, ecological susceptibility, and habitat use of the local receptors, and the spatial distribution of radionuclides in relation to these habitat.
2	Re-run the screening evaluation using revised information from Step 1 (the evaluator can use either the RAD-BCG Calculator or RESRAD-Biota for this step).
3	Assess the representativeness of the exposure parameters used in the derivation of generic BCGs. Determine if the limiting ecological receptor for each radionuclide/environmental medium is relevant to the site-specific habitat conditions of the evaluation area and modify as appropriate. Consider the relevance of the generic transfer factors used to derive BCGs and the availability of site-specific values for these factors. Consider the representativeness of the water:sediment partitioning coefficient (K_d) if it was used in the screening assessment. Site conditions and available information may allow the evaluator to replace the default value used in deriving the generic BCGs with values that are more relevant to the area being evaluated.
4	Re-run the screening evaluation using revised information from Step 1 (the evaluator can use either the RAD-BCG Calculator or RESRAD-Biota for this step).

Site-specific analysis

Overview

In the site-specific analysis, a kinetic/allometric model is used to develop a more rigorous analysis of doses to terrestrial or riparian animals. Appropriate parameters representing individual mechanisms (e.g., ingestion, inhalation) are developed to estimate the contribution to internal dose. Appropriate values that are representative of local receptors can be used in place of default values for parameters such as ingestion and inhalation rates, organism body weights, and biological uptake and elimination rates. Allometric equations can be used to estimate some of these values from known body weights.

Steps in the site-specific analysis

To assemble data, perform the following three steps.

Step	Action
1	Consider using a correction factor for exposure area and receptor residence time. Based upon the distribution of radionuclide concentrations in environmental media and receptor activity habits, only part of the evaluation area may be used by the limiting receptor. In addition, some receptors may be on site for only a portion of the year. Determine if default parameters that relate internal exposure pathways are appropriate for the site-specific conditions and receptors and modify as needed. Review the food-source parameter values to determine if they are representative of the limiting, site-specific receptors and make appropriate modifications.
2	Re-run the screening evaluation using revised information from Step 1 (the evaluator can use either the RAD-BCG Calculator or RESRAD-Biota for this step).

Site-specific biota dose assessment

Additional analysis

The majority of the graded approach to biota dose assessment centers on the use of measured radionuclide concentrations in environmental media for comparison with BCGs. However, if it is determined that additional analysis is needed, actual collection of biota in the evaluation area can be conducted. Collection and analysis of biota tissue can be used to determine radionuclide concentrations in receptor biota in order to calculate a more realistic estimate of the internal dose contributions to a local receptor. Additional analysis may be warranted if the screening and analytical methods described above indicate that there is a potential for adverse impact to local biota from radionuclides released by Laboratory operations. Approaches for implementing such a dose assessment are outlined in DOE-STD-1153-2002 and documents cited therein.

Records resulting from this procedure

Records

The following records generated as a result of this procedure are to be submitted upon completion of the dose assessment as records to the records coordinator:

- The output worksheets of the RAD-BCG Calculator runs and/or output reports from RERAD-Biota runs.
- Documentation of changes in assumptions that were made if default values were not used in making comparisons to BCGs.

Click here to record “self-study” training to this procedure.